GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

8 April 1966

Director of Chemical Development
Tennessee Valley Authority
Muscle Shoals, Alabama 35660

Attention: Mr. Travis P. Hignett

Subject: Quarterly Progress Letter No. 1, Project A-904
"Tests of the Effectiveness of Fertilizer Bulk Blending Equipment"
Covering the period from January 1 through March 31, 1966

Gentlemen:

The objective of this project is to test the effectiveness of various types of mixers being used commercially for bulk blending of fertilizers. To accomplish this, arrangements were made to mix two 1-ton batches of specially prepared fertilizer materials (ammonium nitrate, high analysis superphosphate, and potash) in commercial plants having different types of mixing equipment.

Tests were made on March 10th of a Stedman rotary mixer at Albany, Georgia, and of a Continental screw conveyor mixer at Ashburn, Georgia. A test of an Inglett cone mixer was made at Winnsboro, Louisiana on March 23rd. A test of a Munson rotary mixer was made at Muscle Shoals, Alabama on March 24th. A test of a ribbon mixer was made at Perry, Georgia, on April 6th. Samples from the various tests are being analyzed for N, P_2O_5, and K_2O.

The tests remaining to be done are for a concrete mixer and a tower mixer. The concrete mixer test will be done soon at a plant in Blakely, Georgia. Since a commercial plant using a tower mixer has not been located, this type of unit will be tested at the TVA plant at Muscle Shoals.

Sincerely,

G. L. Bridger
Project Director

GLB/gj

Approved:

F. Bellinger, Chief
Chemical Sciences and Materials Division

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

13 July 1966

Director of Chemical Development
Tennessee Valley Authority
Muscle Shoals, Alabama 35660

Attention: Mr. Travis P. Hignett

Subject: Quarterly Progress Letter No. 2 - Project A-904
"Tests of the Effectiveness of Fertilizer Bulk Blending Equipment"
Covering the period from April 1 through June 30, 1966

Gentlemen:

Plant scale tests were made of a concrete mixer at Blakely, Georgia and of a tower mixer at the TVA plant at Muscle Shoals, Alabama. A pilot plant scale Littleford-Lodige mixer was tested at Georgia Tech. All of the scheduled mixing tests have now been completed.

Samples from the various tests are in the process of analysis.

Sincerely yours,

G. L. Bridger
Project Director

GLB/gj

Approved:

F. Bellinger, Chief
Chemical Sciences and Materials Division

GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station
Atlanta, Georgia

FINAL REPORT

PROJECT A-904

TESTS OF THE EFFECTIVENESS OF FERTILIZER BULK BLENDING EQUIPMENT

By

G. L. Bridger and I. J. Bowen

CONTRACT TV-27894A

1 January 1966 to 31 December 1966

Prepared for
TENNESSEE VALLEY AUTHORITY
DIVISION OF CHEMICAL DEVELOPMENT
Muscle Shoals, Alabama

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I. SUMMARY

Tests were made of the efficiency of mixing units for bulk blending of fertilizers in six plants and of one pilot plant scale mixer. The plant scale mixers tested were a cylindrical rotary mixer, a concrete mixer, a ribbon mixer, a vertical tower mixer, a cone mixer, and a screw mixer. The pilot plant mixer tested was a Munson rotary mixer. Mixing efficiency was judged by deviation from average analysis of a series of samples taken during discharge of the mixer.

Best mixing was achieved by the screw conveyor mixer, which is a continuous mixing unit, but proportioning of the raw materials was poor, so that the product was badly off specifications (17-18-11 instead of 15-15-15). The Munson rotary, cylindrical rotary, and ribbon mixers gave good mixing, even though some samples deviated from specifications sufficiently so that they might fail to pass state inspection. The concrete, cone and vertical tower mixers gave unsatisfactory mixing, and sample analyses varied excessively from beginning to end of the discharge period.

II. INTRODUCTION

Bulk blending of fertilizers has grown to be a major segment of the industry in the past few years. It was estimated that there were 1,536 bulk blending plants in the United States in mid-1964[1]. Most of the plants are small in capacity and serve a limited area.

The equipment used in bulk blending plants for mixing fertilizer materials is of many types; a wide variety of both batch and continuous systems is used. It is recognized that differences in mixing efficiency of the various types exists, but little quantitative information is available on this subject.

It has been shown that if fertilizer raw materials of the same particle size range are well mixed, little segregation will occur even if the materials are of different densities and shapes[2]. However, if the particles differ significantly in size, segregation can take place during discharge from the mixer and in subsequent handling.

There are, therefore, two problems in producing and delivering to the soil a homogeneous bulk blend fertilizer, namely, (1) obtaining good mixing at the point of production, and (2) prevention of segregation of the fertilizer components in subsequent handling.

The present study was undertaken to determine the ability of several types of mixers being used in commercial operations to produce a homogeneous bulk blend fertilizer. Study of the degree of segregation in subsequent handling was beyond the scope of the present investigation.

To accomplish this objective, large batches of specially sized ammonium nitrate, high analysis superphosphate, and potassium chloride were prepared at the TVA chemical plant at Muscle Shoals, Alabama. The particle sizes were chosen so that there were slight differences between each of the three materials, but not enough to prevent a homogeneous mix to be made and discharged from the mixer without excessive segregation. The materials were bagged and a total of two tons sent to each of the various mixing plants. Two one-ton mixes were made at each of the plants, except when a continuous system was used, in which case a single two-ton run was made. A series of samples was taken at the mixer discharge spaced as evenly as possible over the entire discharge period. The samples were analyzed for N, total P_2O_5, and K_2O, and the variations in analysis were used to judge the effectiveness of mixing.

III. EXPERIMENTAL

A. Materials

TVA furnished the raw materials used in the bulk blending tests. Shown below are the raw materials used, TVA screen analyses of these materials, and TVA chemical analyses of these materials.

Screen Analyses (Tyler)

Material	% by Weight (Cumulative)							
	6	8	10	12	14	16	20	-20
Ammonium nitrate	0.1	39.7	84.7	92.3	96.3	98.4	99.4	0.6
Granular high-analysis superphosphate	0	15.3	44.3	61.5	78.0	88.6	94.7	5.3
Potassium chloride (red granular)	0.3	22.7	71.9	82.3	87.8	91.4	94.3	5.7

	% by Weight of Screen Fraction							
	+6	-6+8	-8+10	-10+12	-12+14	-14+16	-16+20	-20
Ammonium nitrate	0.1	39.6	45.0	7.6	4.0	2.1	1.0	0.6
Granular high-analysis superphosphate	0.0	15.3	29.0	17.2	16.5	10.6	6.1	5.3
Potassium chloride (red granular)	0.3	22.4	49.2	10.4	5.5	3.6	2.9	5.7

	Chemical Analyses, % by Weight						
		P_2O_5					
	N	Total	C.I.	W.S.	F.A.	K_2O	H_2O
Ammonium nitrate	33.4	----	----	----	----	----	----
Granular high-analysis superphosphate	----	54.0	1.6	49.4	1.0	----	0.8
Potassium chloride (red granular)	----	----	----	----	----	59.8	----

B. Description of Mixers

1. Cylindrical Rotary Mixer

This mixer was cylindrical and had the following dimensions: diameter = 78 inches, length = 32 inches. It had a 1-ton batch capacity and operated at a speed of 12 RPM. The mixer was a Stedman Batch Mixer R 1-ton, serial no. BM 739 made by Stedman Foundry & Machine Company, Inc., Aurora, Indiana.

The rotary mixer was placed on two wheel drive rubber-tired trunnions which provided the rotary motion for the cylinder. The interior discharge was actuated by air operated controls.

The raw materials were conveyed by payloader to a weigh hopper which discharged into the 1-ton Stedman rotary mixer. The blended fertilizers were then discharged from the mixer into an elevator which conveyed the blend into a truck outside the building.

2. Concrete Mixer

The concrete mixer was a 2-ton rotary batch type with a fixed, inclined axis and helical flights. With mixers of this type, which are similar to those used on concrete ready-mix trucks, the blend was discharged by reversing rotation; this caused the helical flight to move the blend upward and out of the mixer. The mixer was charged by gravity flow from a weigh hopper. It discharged through a chute which conveys the blend to a bucket elevator which conveys the material to another chute and then to the truck.

The geometry of the mixer was comparable to a frustrum of a cone with a small diameter of about 3 feet and a large diameter of about 6 feet. The mixer was positioned horizontally with its axis slightly inclined, the center of the large end was about 20 inches lower than the center of the smaller end. The mixer working capacity was 2 tons. The drum speed was 14 RPM.

3. Ribbon Mixer

The ribbon mixer had a 1-ton capacity. It had a U-trough design and a total internal volume of about 50 cubic feet. Overall dimensions were 30 inches wide x 38 inches high x 9 feet 10 inches long. The unit had two multiple ribbons blending flights with a double extra heavy pipe and trough of steel. The blender gate was located at one end and was air operated.

Fertilizer materials were conveyed to the mixer by payloader. The mixer was located on weighing scales which were adjusted to zero after each mix. Mixing was accomplished by the rotating spiraling motion of the ribbon blades and the mix was discharged at one end of the blender through the hydraulically operated discharge gate. From here it fell by gravity to a screw conveyor where it was conveyed to bucket elevators and to a discharge chute to a truck.

4. Vertical Tower Mixer

This mixer was developed by TVA and is described by Achorn and Meline[3]. The tower, which is made of wood, is 4 feet square by 28 feet high. The top 4 feet is used as a collecting hopper. The floor of the hopper is in the form of a trap door. The lower 24 feet of the tower serves as a mixing section and is provided with five baffles. Two diagonal flights extend across each baffle. In operating the tower, the raw materials are weighed and then elevated to the retaining section with the gate closed. When all the materials have been added, the gate is opened, and the mixing of the materials is accomplished as they pass over the steps and flights of the tower. This system is designed for the weighing and mixing of 1-ton batches of fertilizer. Production rates of 14 tons per hour may be obtained with it.

5. Cone Mixer

The cone mixer was an Inglett Triple Effect Conical Mixer made by Inglett Development & Engineering Associates, Inc., Augusta, Georgia. The capacity of this mixer was one ton.

From overhead storage bins, raw ingredients were gravity fed into a weigh hopper. The raw mix was then belt conveyed to bucket elevators which conveyed it to a vibrating conveyor. The material flowed to the cone mixer by gravity around the upper inverted cone and to the closed top gate. The mix was retained momentarily at this point. The top gate was opened and the material flowed around the middle inverted cone to the bottom gate which was closed. After a momentary retention the bottom gate was opened and the material flowed around the bottom inverted cone and out the discharge chute to a truck.

Mixing was accomplished as the fertilizer materials flowed over and around three inverted cones.

6. Screw Conveyor Mixer

The screw conveyor mixer tested was a Continental Complete Blend-O-Mixer Plant. The specifications are as follows:

size - 12 feet long x 5 feet wide x 7 feet high
weight - 4,000 pounds
belt - endless, 5 ply, extra-heavy duty
motors - belt motor is 2 HP; double gear head auger motor, $1\frac{1}{2}$ HP.
auger - specially designed mixing unit

The screw conveyor mixer had a capacity of producing 20 tons of blend per hour. Automatic controls. The master control panel electronically activated the motors to elevate the raw ingredients to overhead bins, run the Blend-O-Mixer and re-elevate the finished product. Blend-O-Mixer. Raw ingredients from overhead bins feed into the sloping floor of the blender, under the gates, onto the endless rubber belt. A special baffling system, plus a mixing auger blended the fertilizer. The blended material was then transferred to truck or was bagged.

Prior to mixing, the bulk densities of the raw materials that were used in the test were determined. The bulk density of the ammonium nitrate, superphosphate and potassium chloride were 55.0, 64.2, and 67.2 pounds per cubic foot respectively. The purpose of measuring these bulk densities was to be able to set the Blend-O-Mixer feed control gates at the proper calibration for continuous mixing.

7. Munson Rotary Mixer

This mixer was made by the Munson Mill Machinery Company, Inc., Utica, New York. It operated at a speed of 20 RPM and had a 15 cubic foot capacity. The mixer was mounted in a horizontal position. Its geometry can be described as a cylinder joined by a cone frustrum closure on one end and a hemispherical closure on the other end. The diameter of the drum was 42 inches and the overall length was about 36 inches. The mixer was operated by a gear at one end connected by a shaft driven to an electric motor. The mixer was Model MX-15-S, serial no. FM-1510-C. The mixer was charged through a door located on the cylindrical part of the drum. It discharges through a manually operated door located on one end of the mixer. No tilting of the mixer is necessary during discharge, because the internal blades are designed to move the mix up and out through the opening at the discharge end.

C. Test Procedures

1. Mixing

(a) Two batches were made in most tests. Each batch weighed 1,975 pounds, except for the pilot plant scale mixer test.

(b) The following amounts of raw materials were used:

Raw Material		Amount, Pounds
Granular Ammonium Nitrate (33.4-0-0)		900
Granular Superphosphate (0-52.4-0)		575
Granular Red Potassium Chloride (0-0-59.8)		500
	Total:	1,975

These proportions of materials would result in a mixed fertilizer of the following analysis, based on the TVA analyses of the materials:

N	15.2%
Total P_2O_5	15.7%
Available P_2O_5	15.2%
K_2O	15.2%

(c) The mixer was charged with raw materials and mixed for one minute.

2. Sampling

(a) A small quantity (about 100 grams) of each raw material was removed from each bag used in the test and placed in separate containers. When samples were collected from the raw materials of both mixes, they were riffled into two quart samples, placed in moisture-proof containers and identified. This constitutes a composite sample of each raw material representative of the two mixes.

(b) Ten-quart buckets were used to collect 20 samples (or as many as practical) from the mixer discharge of each test mix. In most cases, two quarts of blend per bucket were collected from the discharging stream of blend. The samples were collected at timed intervals from the start of discharge to the end of discharge.

When all of the samples were collected from a test mix, each was riffled into two quarts, placed in moisture-proof containers and identified. This operation yielded identical samples, one of which was used for chemical analysis and one of which was placed in reserve. Forty quart samples were obtained when all 20 samples were riffled.

3. Sample Preparation

(a) One quart-size sample was ground in the Mikro-Samplmill in half-quart batches. An 0.039 inch round hole screen was used in the mill during grinding. After grinding the two batches were combined and riffled to a 2-ounce sample. This sample was placed in a moisture-proof container and identified. This operation was performed as rapidly as possible to avoid moisture absorption by the sample. The mill was thoroughly cleaned after each grinding to avoid contamination of the next sample to be ground.

4. Chemical Analyses

Standard AOAC procedures were used to determine nitrogen, total P_2O_5, and K_2O. Listed below are the methods used.

(a) Nitrogen. Devarda Method - official. Paragraph 2.053, page 17, Association of Official Agricultural Chemicals, 10th edition, 1965.

(b) Total P_2O_5. Volumetric Ammonium-Molybdate Method - official. Paragraph 2.026, 2.027, 2.028, page 13, Association of Official Agricultural Chemicals, 10th edition, 1965.

(c) K_2O. Volumetric Sodiumtetraphenylboron - official. Paragraph 2.083, 2.084, 2.085, page 23, Association of Official Agricultural Chemicals, 10th edition, 1965.

The 2-ounce samples ground in the Mikro-Samplemill were used for the chemical analysis. The 2-ounce sample was poured on a cloth and mixed thoroughly before taking a sample for chemical analysis.

5. Deviations from Test Procedures

(a) Screw Conveyor Mixer. Since the screw conveyor mixer was a continuous mixer, only one mix was made. The entire two tons of materials were mixed in a single run. Because of the limited working area at the screw discharge area, buckets could not be used so the samples were collected in pint jars. A total of 25 samples were collected at the mixer discharge.

(b) Cone Mixer. Due to the rapid discharge of this mixer only 12 samples could be collected from test mix 1 and 17 from test mix 2.

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(b) Cone Mixer. Due to the rapid discharge of this mixer only 12 samples could be collected from test mix 1 and 17 from test mix 2.

(c) Munson Rotary Mixer. Due to the limited working capacity of this mixer, the size of the test mixes were reduced to 494 pounds. The following amounts of raw materials were used per mix:

Raw Material	Amount, Pounds
Granular Ammonium Nitrate (33.4-0-0)	225
Granular Superphosphate (0-52.4-0)	144
Granular Red Potassium Chloride (0-0-59.8)	125
Total:	494

(d) Ribbon Mixer. The raw materials for test mix 1 were poured into the mixer in sections and thorough mixing did not take place, as was obvious by visual inspection. Test mix 1 was therefore mixed for 5 minutes rather than 1 minute, as would normally be the case. Test mix 2 was also mixed for 5 minutes. Due to limited working area at the mixer discharge, buckets could not be used to collect samples, so trays were made from paperboard and used instead.

(e) Tower Mixer. Due to the rapid discharge of this mixer only 10 samples were collected from test mix 1 and 16 from test mix 2.

(f) Analytical. The K_2O determinations in the cylindrical rotary mixer and cone mixer tests were carried out by the flame photometric method. Association of Official Agricultural Chemicals, Methods of Analysis, Paragraph 2.077, 2.082, pp. 22-23, 10th edition (1965).

IV. RESULTS AND DISCUSSION

A. Interpretation of Results

The following method was adopted to analyze the results from the tests. The deviation of each plant nutrient determination from the average was used as a measure of the failure to achieve perfect mixing of a single sample. Although this deviation also reflects variations due to sample preparation and analytical error, it is believed that the latter are relatively small compared to variations due to imperfect mixing.

The average deviation for each plant nutrient for an entire test indicates the probable difference between a sample taken at random during the discharge of the mixer and the average composition of the entire batch, and thus is an indication of the probable deviation of an inspector's sample from the guaranteed value, assuming that the proper amounts of plant nutrients were fed into the mixer. The average composition of the test batch may be in slight error since the individual samples do not represent precisely the same fraction of the total batch, but since the number of samples is large, this error is probably small.

Plots were made of the deviation of each determination from the average versus sample number, to show any trends in variation in analysis during the discharge period. A flat curve would indicate no variation in composition from beginning to end.

Screen analyses were made on each sample, and these were averaged for each particle size range. Weighted screen analyses for each particle size range were calculated from the screen analyses of the raw materials, and compared with the averages of the mixture samples, to determine whether degradation took place in mixing.

B. Cylindrical Rotary Mixer Tests

The results of the cylindrical rotary mixer tests are shown in Tables I and II, and in Figure 1. Average deviations were greatest for total P_2O_5 (0.70 and 1.49), less for K_2O (0.59 and 1.07) and lowest for nitrogen (0.52 and 0.32). Analyses of individual samples ranged from 15-12-18 to 15-18-14. There was a slight trend for P_2O_5 content to increase as discharge proceeded. There was no degradation in particle size.

This mixer did a satisfactory job of mixing on the whole.

C. Concrete Mixer Tests

The results of the concrete mixer tests are shown in Tables III and IV, and in Figure 2. Average deviations were rather large (1.17 to 2.15). There was a very pronounced increase in P_2O_5 content as discharge proceeded, with corresponding decrease in N and K_2O. Individual samples varied from 17-13-17 at the beginning to 14-23-12 at the end. Screen analyses showed no significant degradation in particle size during mixing.

Mixing in this unit must be rated as unsatisfactory.

D. Ribbon Mixer Tests

The results of the ribbon mixer tests are shown in Tables V and VI, and in Figure 3. The average deviations were large (0.76 to 2.43). Except for the first and last samples, there was no pronounced trend in sample analysis as discharge proceeded. Individual sample analyses ranged from 10-11-33 to 13-20-13. Screen analyses showed no appreciable degradation.

E. Vertical Tower Mixer Tests

The results of the vertical tower mixer tests are shown in Tables VII and VIII, and in Figure 4. Average deviations were greater than for any other mixer tested (1.33 to 3.78). There were pronounced trends in all three nutrients as discharge proceeded. Analyses of products ranged from 15-17-12 to 8-20-22. The fact that the average analyses for both tests differed significantly from a 1-1-1 ratio seems to indicate an error in proportioning of the raw materials. There was no appreciable degradation in particle size.

The mixing in this unit must be rated as unsatisfactory.

F. Cone Mixer Tests

The results of the cone mixer tests are shown in Tables IX and X, and in Figure 5. Average deviations were large (1.17 to 2.15). There was a pronounced decrease in N content and a corresponding increase in P_2O_5 content as discharge proceeded. Analyses of products ranged from 17-13-13 to 11-20-15. There was no appreciable degradation in particle size.

Mixing in this unit must be rated as unsatisfactory.

G. Screw Conveyor Mixer Tests

The results of the screw conveyor mixer tests are shown in Tables XI and XII, and in Figure 6. Average deviations were the lowest of all tests made (0.23 to 0.59). There were no pronounced trends in plant nutrient content. The composition of the product was very uniform from beginning to end of the mixing period, but the average analysis was 17-18-11, indicating that proportioning of raw materials was poor. This was borne out by the fact that the ammonium nitrate and superphosphate bins were emptied before the potash bin, and sampling was stopped when all three materials were no longer being fed into the mixer. Screen analyses showed no degradation of materials.

It must be concluded that whereas uniformity of material feed rates and mixing in the screw conveyor mixer were very good, the raw materials proportioning was unsatisfactory.

H. Munson Rotary Mixer Tests

The results of the Munson rotary mixer tests are shown in Tables XIII and XIV, and in Figure 7. Deviations from average analyses were low (0.27 to 0.93). There were no pronounced trends in sample analysis from beginning to end. The average product analysis was about 14-17-15, again suggesting an error in proportioning of ingredients. There was no appreciable change in screen analysis after mixing.

The overall performance of this mixer is rated as the best of those tested.

I. Comparison of Mixing Efficiency

The best index of mixing efficiency is believed to be the average deviation from the average analysis of each plant nutrient. Based on this criterion, the various mixers are listed in order of decreasing mixing efficiency in Table XV.

The mixer giving best mixing, namely the screw conveyor, unfortunately produced a product badly off the desired analysis of 15-15-15 because of the poor proportioning. It is evident that the raw material feeders delivered a uniform flow of materials to the mixer, and mixing was good, but the flow rates were not as desired.

The Munson rotary mixer, the cylindrical rotary mixer, and the ribbon mixer gave good mixing, and there was no decided difference in analysis of samples from beginning to end of discharge, except for the first and last samples from the ribbon mixer. With all of these mixers there is a good possibility of producing samples that would not meet state inspectors' standards, but it is doubtful that the variability in sample analysis would be of agronomic significance.

The concrete mixer, the cone mixer, and the vertical tower mixer all gave unsatisfactory mixing, both with respect to average deviation and variability of sample analysis.

All of the mixers except the screw conveyor mixer were operated batchwise, and the raw materials for each test were fed as measured batches; this was done by feeding the proper number of bags, each of which had been weighed, and making a final weight adjustment of the entire batch which was weighed on scales. If the raw material analyses and batch weights were correct, the average analyses of the mixes should have been exactly 15.2% N, 15.7% total P_2O_5, and 15.2% K_2O. In some tests the average analyses differed significantly from these figures. This could have been due to many reasons, such as contamination, errors in weighing the raw materials, non-uniformity of sampling pattern, errors in sample preparation, and errors in analysis. However, these errors should not affect the validity of the use of average deviation as a criterion of mixing, even though they would affect the absolute values of the plant nutrient content.

V. CONCLUSIONS

1. The best mixing achieved in the tests was by the screw conveyor mixer, but because of poor proportioning the product analysis was substantially off specifications.

2. Good mixing was achieved by the Munson rotary, cylindrical rotary, and ribbon mixers. Variations in sample analysis during discharge were great enough to result in failure to meet state inspectors' standards, but probably not great enough to affect agronomic results.

3. Mixing achieved by the concrete, cone, and vertical tower mixers was unsatisfactory, and deviation in analysis of individual samples from specifications was excessive.

VI. REFERENCES

1. Hignett, T. P., "Proceedings No. 87" of The Fertilizer Society, March 25, 1965.

2. Hoffmeister, G., Watkins, S. C., and Silverberg, J., J. Ag. and Food Chem. 12, 64-9 (1964).

3. Achorn, F. P. and Meline, R. S., Commercial Fertilizer and Plant Food Industry 110, 32-3 (1965).

VII. ACKNOWLEDGMENTS

This project was supported financially by the Division of Chemical Development of the Tennessee Valley Authority. In addition, several of the TVA personnel assisted in planning and carrying out the tests, including Frank Achorn, Frank Anderson, Ralph Cunningham, Al Gordon, George Hoffmeister, Robert Meline, and L. M. Nunnelly.

TABLE I. CYLINDRICAL ROTARY MIXER TESTS: CHEMICAL ANALYSES

Sample No.	% N	Deviation from N Average	Total % P_2O_5	Deviation from P_2O_5 Average	% K_2O	Deviation from K_2O Average
TEST 1						
1A	15.36	- 0.24	14.64	- 0.89	16.00	+ 0.61
2A	15.36	- 0.24	15.23	- 0.30	16.20	+ 0.81
3A	15.26	- 0.34	15.69	+ 0.16	15.30	- 0.09
5A	15.16	- 0.44	15.92	+ 0.39	16.40	+ 1.01
6A	15.05	- 0.55	16.06	+ 0.53	16.60	+ 1.21
8A	15.88	+ 0.28	15.65	+ 0.12	15.60	+ 0.21
9A	15.83	+ 0.23	14.94	- 0.59	15.50	+ 0.11
11A	16.09	+ 0.49	15.23	- 0.30	14.70	- 0.69
12A	16.24	+ 0.64	14.48	- 1.05	15.60	+ 0.21
14A	16.50	+ 0.90	13.88	- 1.65	14.80	- 0.59
15A	16.71	+ 1.11	13.58	- 1.95	14.20	- 1.19
17A	16.09	+ 0.49	14.70	- 0.83	15.90	+ 0.51
18B	16.16	+ 0.56	15.36	- 0.17	15.20	- 0.19
20B	15.76	+ 0.16	15.47	- 0.06	15.10	- 0.29
21	15.40	- 0.20	15.79	+ 0.26	16.00	+ 0.61
23	15.37	- 0.23	16.14	+ 0.61	13.90	- 1.49
24	15.03	- 0.57	16.29	+ 0.76	16.30	+ 0.91
26	14.67	- 0.93	16.62	+ 1.09	15.10	- 0.29
27	14.62	- 0.98	17.05	+ 1.52	15.00	- 0.39
29	14.57	- 1.03	17.48	+ 1.95	15.70	+ 0.31
30	16.07	+ 0.47	15.48	- 0.05	14.50	- 0.89
31	16.02	+ 0.42	15.88	+ 0.35	15.00	- 0.39
Average	15.60	0.52	15.53	0.71	15.39	0.59
TEST 2						
1B	14.55	- 0.63	12.37	- 4.15	17.90	+ 2.74
2B	15.76	+ 0.58	13.12	- 3.40	18.80	+ 3.64
3B	15.16	- 0.02	14.64	- 1.88	17.40	+ 2.24
4B	14.74	- 0.44	15.31	- 1.21	16.20	+ 1.04
5B	14.74	- 0.44	15.61	- 0.91	15.30	+ 0.14
6B	15.26	+ 0.08	16.29	- 0.23	14.60	- 0.56
7B	15.36	+ 0.18	15.61	- 0.91	13.90	- 1.26
8B	15.77	+ 0.59	15.69	- 0.83	14.60	- 0.56
9B	14.74	- 0.44	16.00	- 0.52	16.70	+ 1.54
10B	14.69	- 0.49	16.14	- 0.38	14.80	- 0.36
11B	15.88	+ 0.70	16.06	- 0.46	14.70	- 0.46
12B	15.57	+ 0.39	16.59	+ 0.07	13.90	- 1.26
13B	15.16	- 0.02	16.89	+ 0.37	15.60	+ 0.44
14B	14.48	- 0.70	17.95	+ 1.43	14.80	- 0.36
15B	14.84	- 0.34	18.25	+ 1.73	13.70	- 1.46
16B	15.45	+ 0.27	18.77	+ 2.25	13.60	- 1.56
17B	15.54	+ 0.36	17.87	+ 1.35	14.40	- 0.76
18B	15.72	+ 0.54	19.16	+ 2.64	14.00	- 1.16
19B	15.08	- 0.10	19.46	+ 2.94	14.20	- 0.96
20B	15.16	- 0.02	18.70	+ 2.18	14.00	- 1.16
Average	15.18	0.37	16.52	1.49	15.16	1.07
Raw Materials						
AN	32.84					
SP			53.60			
KCl					60.2	

TABLE II. CYLINDRICAL ROTARY MIXER TESTS: SCREEN ANALYSES

	% of Total						
Sample No.	+ 8 mesh	- 8 + 10	- 10 + 12	- 12 + 14	- 14 + 16	- 16 + 20	- 20
TEST 2							
1A	31.2	51.1	9.1	5.0	2.6	0.7	0.3
2A	32.4	49.3	9.1	5.3	2.6	1.1	0.2
3A	31.0	47.1	9.3	6.9	3.6	1.5	0.6
4A	30.4	47.8	9.1	6.6	3.4	1.8	0.9
5A	26.8	47.5	10.1	7.6	4.6	2.0	1.4
6A	27.6	45.4	9.7	8.1	5.2	2.5	1.5
7A	27.8	46.6	10.1	7.9	4.4	2.0	1.2
8A	27.1	45.9	10.3	8.7	4.9	2.1	1.0
9A	26.7	46.9	10.0	8.0	4.6	2.2	1.6
10A	24.8	46.0	10.6	8.5	5.1	3.2	1.8
11A	21.2	45.7	11.8	9.7	6.4	2.7	2.5
12A	24.3	45.0	10.8	8.8	5.7	2.4	3.0
13A	20.5	45.7	12.0	10.2	6.1	2.5	3.0
14A	19.9	42.9	12.1	10.2	7.2	3.1	4.6
15A	19.9	43.0	11.7	10.7	7.5	3.3	3.9
16A	17.8	39.6	12.5	11.8	8.8	4.1	5.4
17A	17.2	39.3	11.4	11.5	8.7	4.4	7.5
18A	17.1	39.1	11.4	11.5	8.6	4.1	8.1
19A	16.8	38.2	11.5	11.9	9.0	5.0	7.6
20A	14.7	38.3	11.2	11.6	7.9	9.2	7.1
Average	23.8	44.5	10.7	9.0	5.8	3.0	3.2
Raw Materials							
AN	30.5	51.4	8.8	5.9	2.3	0.8	0.3
SP	11.8	29.0	15.7	16.9	12.1	5.5	9.0
KCl	17.8	49.5	10.1	7.1	5.1	3.3	7.1
Wt. Avg.	21.8	44.4	11.1	9.4	5.9	2.8	4.6

TABLE III. CONCRETE MIXER TESTS: CHEMICAL ANALYSES

Sample No.	% N	Deviation from N Average	Total % P_2O_5	Deviation from P_2O_5 Average	% K_2O	Deviation from K_2O Average
TEST 1						
1B	17.25	+ 2.06	11.80	- 6.25	17.00	+ 2.33
2B	15.60	+ 0.41	13.42	- 4.63	17.60	+ 2.93
3B	15.50	+ 0.31	13.50	- 4.55	17.40	+ 2.73
4B	16.15	+ 0.96	13.20	- 4.85	17.20	+ 2.53
5B	16.00	+ 0.81	14.87	- 3.18	16.40	+ 1.73
6B	15.70	+ 0.51	14.50	- 3.55	16.40	+ 1.73
7B	16.25	+ 1.06	17.20	- 0.85	15.60	+ 0.93
8B	16.65	+ 1.46	19.75	+ 1.70	15.20	+ 0.53
9B	15.80	+ 0.61	18.61	+ 0.56	15.40	+ 0.73
10B	16.35	+ 1.16	15.94	- 2.11	15.00	+ 0.33
11B	15.50	+ 0.31	17.43	- 0.62	14.60	- 0.07
12B	15.65	+ 0.46	17.60	- 0.45	14.00	- 0.67
13B	14.75	- 0.44	18.92	+ 0.87	13.80	- 0.87
14B	14.65	- 0.54	20.05	+ 2.00	13.00	- 1.67
15B	14.30	- 0.89	20.24	+ 2.19	13.20	- 1.47
16B	13.55	- 1.64	21.76	+ 3.71	13.00	- 1.67
17B	13.20	- 1.99	22.86	+ 4.81	12.40	- 2.27
18B	13.60	- 1.59	22.50	+ 4.45	12.20	- 2.47
19B	13.65	- 1.54	23.90	+ 5.85	12.00	- 2.67
20B	13.75	- 1.44	23.00	+ 4.95	12.00	- 2.67
Average	15.19	1.01	18.05	3.11	14.67	1.65
TEST 2						
1B	17.85	+ 2.01	12.75	- 2.46	16.00	+ 0.90
2B	16.65	+ 0.81	14.88	- 0.33	15.60	+ 0.50
3B	16.45	+ 0.61	14.75	- 0.46	16.00	+ 0.90
4B	16.40	+ 0.56	14.88	- 0.33	15.80	+ 0.70
5B	15.35	- 0.49	15.43	+ 0.22	15.80	+ 0.70
6B	16.35	+ 0.51	14.92	- 0.29	15.40	+ 0.30
7B	16.20	+ 0.36	14.30	- 0.91	15.60	+ 0.50
8B	16.80	+ 0.96	14.75	- 0.46	15.20	+ 0.10
9B	17.60	+ 1.76	10.80	- 4.41	14.60	- 0.50
10B	16.30	+ 0.46	9.82	- 5.39	15.20	+ 0.10
11B	17.05	+ 1.21	12.93	- 2.28	14.60	- 0.50
12B	16.75	+ 0.91	14.63	- 0.58	14.60	- 0.50
13B	16.10	+ 0.26	15.62	+ 0.41	15.20	+ 0.10
14B	15.65	- 0.19	15.25	+ 0.04	14.80	- 0.30
15B	14.75	- 1.09	16.70	+ 1.49	15.20	+ 0.10
16B	14.95	- 0.89	18.12	+ 2.91	14.60	- 0.50
17B	13.75	- 2.09	18.57	+ 3.36	14.40	- 0.70
18B	14.00	- 1.84	16.75	+ 1.54	14.40	- 0.70
19B	13.50	- 2.34	17.80	+ 2.59	14.80	- 0.30
20B	14.25	- 1.59	20.50	+ 5.29	14.20	- 0.90
Average	15.84	1.05	15.21	1.79	15.10	0.49
Raw Materials						
AN	34.00					
SP			55.20			
KCl					57.60	

TABLE IV. CONCRETE MIXER TESTS: SCREEN ANALYSES

	% of Total						
Sample No.	+ 8 mesh	- 8 + 10	- 10 + 12	- 12 + 14	- 14 + 16	- 16 + 20	- 20
TEST 2							
1A	30.4	53.8	8.3	4.7	0.9	0.5	0.4
2A	19.1	47.0	12.0	10.4	6.5	2.8	2.1
3A	22.6	47.4	10.9	9.0	5.4	2.5	2.1
4A	20.6	46.1	11.1	9.8	6.0	3.0	3.3
5A	20.0	44.0	11.0	9.9	6.4	3.4	5.3
6A	23.9	50.1	10.0	7.6	4.1	1.9	2.4
7A	22.8	46.1	10.9	9.2	5.4	2.9	4.0
8A	25.5	48.1	9.7	7.8	4.3	2.0	2.6
9A	22.8	48.8	10.5	8.3	4.7	2.1	2.7
10A	25.3	48.1	10.1	7.7	4.4	2.1	2.3
11A	24.5	48.0	10.3	8.3	4.6	2.1	2.3
12A	22.9	48.2	11.1	8.6	4.5	2.2	2.5
13A	26.3	47.7	9.9	7.6	4.2	1.9	2.4
14A	25.3	46.3	10.8	8.6	4.7	2.2	2.5
15A	22.0	45.6	11.0	9.7	5.9	2.5	3.2
16A	26.1	47.6	10.2	7.8	4.1	1.7	2.5
17A	23.8	45.5	10.3	8.9	4.7	2.5	4.3
18A	22.3	44.6	10.8	9.6	6.1	3.1	3.5
19A	22.0	44.5	10.8	10.3	5.9	2.8	3.6
20A	29.7	45.1	8.7	3.9	4.2	2.0	2.8
Average	23.9	47.1	10.4	8.4	4.9	2.3	2.8
Raw Materials							
AN	31.9	50.0	8.2	5.1	2.9	1.0	0.6
SP	14.7	30.4	15.5	15.1	8.6	6.2	8.8
KCl	18.8	51.8	9.3	6.3	4.0	2.9	6.4
Wt. Avg.	23.7	44.7	10.6	8.3	4.8	3.0	4.5

TABLE V. RIBBON MIXER TESTS: CHEMICAL ANALYSES

Sample No.	% N	Deviation from N Average	Total % P_2O_5	Deviation from P_2O_5 Average	% K_2O	Deviation from K_2O Average
TEST 1						
1B	9.60	- 4.59	11.56	- 4.11	33.50	+ 18.44
2B	15.00	+ 0.81	13.45	- 2.22	18.50	+ 3.44
3B	15.15	+ 0.96	13.83	- 1.84	16.62	+ 1.56
4B	15.65	+ 1.46	13.30	- 2.37	15.60	+ 0.54
5B	15.40	+ 1.21	15.03	- 0.64	15.37	+ 0.31
6B	14.90	+ 0.71	16.13	+ 0.46	14.30	- 0.76
7B	15.55	+ 1.36	16.40	+ .73	14.50	- 0.56
8B	15.60	+ 1.41	17.00	+ 1.33	13.22	- 1.84
9B	13.80	- 0.39	15.47	- .20	13.66	- 1.40
10B	14.95	+ 0.76	14.60	- 1.07	13.02	- 2.04
11B	13.55	- 0.64	15.77	+ 0.10	13.22	- 1.84
12B	13.30	- 0.89	16.90	+ 1.23	13.43	- 1.63
13B	13.80	- 0.39	15.77	+ 0.10	13.66	- 1.40
14B	14.35	+ 0.16	15.83	+ 0.16	13.22	- 1.84
15B	14.45	+ 0.26	16.12	+ 0.45	13.22	- 1.84
16B	14.35	+ 0.16	14.30	- 1.37	12.60	- 2.46
17B	14.55	+ 0.36	14.13	- 1.54	13.43	- 1.63
18B	13.20	- 0.99	17.90	+ 2.23	13.43	- 1.63
19B	13.05	- 1.14	19.57	+ 3.90	13.88	- 1.18
20B	13.50	- 0.69	20.30	+ 4.63	12.80	- 2.26
Average	14.19	0.97	15.67	1.53	15.06	2.43
TEST 2						
1B	19.29	+ 4.24	11.14	- 4.95	12.70	- 2.72
2B	14.98	- .07	14.59	- 1.50	16.10	+ 0.68
3B	15.07	+ .02	14.37	- 1.72	15.70	+ 0.28
4B	12.54	- 2.51	15.47	- 0.62	16.00	+ 0.58
5B	15.34	+ 0.29	15.66	- 0.43	15.80	+ 0.38
6B	16.67	+ 1.62	15.99	- 0.10	18.20	+ 2.78
7B	14.78	- 0.27	15.63	- 0.46	15.60	+ 0.18
8B	15.39	+ 0.34	16.63	+ 0.54	14.60	- 0.82
9B	15.37	+ 0.32	15.25	- 0.84	15.80	+ 0.38
10B	15.21	+ 0.16	15.60	- 0.49	15.70	+ 0.28
11B	15.60	+ 0.55	15.81	- 0.28	16.10	+ 0.68
12B	15.11	+ 0.06	16.67	+ 0.58	14.30	- 1.12
13B	15.09	+ 0.04	16.76	+ 0.67	15.90	+ 0.48
14B	14.26	- 0.79	16.73	+ 0.64	16.00	+ 0.58
15B	13.98	- 1.07	17.84	+ 1.75	14.60	- 0.82
16B	14.57	- 0.48	17.81	+ 1.72	14.90	- 0.52
17B	14.57	- 0.48	16.73	+ 0.64	16.00	+ 0.58
18B	14.42	- 0.63	17.44	+ 1.35	15.70	+ 0.28
19B	14.52	- 0.53	17.87	+ 1.78	15.20	- 0.22
20B	14.16	- 0.89	17.76	+ 1.67	13.50	- 1.92
Average	15.05	0.77	16.09	1.14	15.42	0.81
Raw Materials						
AN	33.1					
SP			50.40			
KCl					60.15	

TABLE VI. RIBBON MIXER TESTS: SCREEN ANALYSES

Sample No.	% of Total + 8 mesh	- 8 + 10	- 10 + 12	- 12 + 14	- 14 + 16	- 16 + 20	- 20
TEST 2							
1A	25.5	48.5	10.2	6.8	3.6	1.8	3.7
2A	21.7	44.9	11.6	9.9	5.2	2.5	4.1
3A	23.5	46.4	10.9	8.6	4.7	2.1	3.8
4A	19.5	45.6	12.6	10.1	5.0	3.2	4.0
5A	19.6	45.0	11.4	9.9	6.2	2.7	5.2
6A	19.1	45.5	11.6	10.3	5.7	2.8	4.9
7A	21.0	45.2	11.3	9.8	5.4	2.6	4.7
8A	17.9	44.0	13.1	10.9	6.3	3.0	5.1
9A	25.2	47.5	10.5	8.1	3.9	2.1	2.8
10A	26.0	47.7	10.1	7.5	4.2	1.8	2.9
11A	20.7	45.8	10.3	10.8	5.5	2.7	4.2
12A	17.7	43.3	12.5	10.5	6.5	3.3	6.2
13A	17.9	44.0	12.1	10.5	7.3	3.0	5.1
14A	14.0	40.2	12.2	11.7	7.5	4.5	10.1
15A	15.8	38.0	11.7	11.6	7.4	4.4	12.0
16A	19.4	44.0	11.7	10.1	5.8	2.9	6.1
17A	14.3	39.9	12.5	11.3	7.8	4.2	10.1
18A	16.7	42.3	11.3	10.9	6.8	3.4	8.6
19A	14.6	40.2	12.2	11.8	7.8	4.0	9.5
20A	12.6	36.9	11.8	12.2	8.3	4.6	13.6
Average	19.1	43.8	11.6	10.2	6.0	3.1	6.3
Raw Materials							
AN	34.5	50.3	7.1	5.0	2.1	0.5	0.4
SP	12.3	30.3	16.3	18.5	11.5	5.7	5.4
KCl	17.6	46.6	9.3	6.9	5.4	4.0	10.1
Wt. Avg.	23.8	43.5	10.3	9.4	5.7	2.9	4.3

TABLE VII. VERTICAL TOWER MIXER TESTS: CHEMICAL ANALYSES

Sample No.	% N	Deviation from N Average	Total % P_2O_5	Deviation from P_2O_5 Average	% K_2O	Deviation from K_2O Average
TEST 1						
1B	15.00	+ 1.66	17.86	+ 1.53	12.65	- 3.53
2B	15.95	+ 2.61	14.00	- 2.33	12.90	- 3.28
3B	16.50	+ 3.16	13.73	- 2.60	10.72	- 5.46
4B	14.65	+ 1.31	16.74	+ 0.41	14.39	- 1.79
5B	14.60	+ 1.26	14.61	- 1.72	15.68	- 0.50
6B	14.70	+ 1.36	16.74	+ 0.41	14.60	- 1.58
7B	12.55	- 0.79	16.74	+ 0.41	17.60	+ 1.42
8B	10.55	- 2.79	17.50	+ 1.17	20.60	+ 4.42
9B	9.50	- 3.84	16.74	+ 0.41	22.50	+ 6.32
10B	9.40	- 3.94	18.60	+ 2.27	20.20	+ 4.02
Average	13.34	2.27	16.33	1.33	16.18	3.23
TEST 2						
1B	15.00	+ 1.72	16.23	- 0.10	12.23	- 3.94
2B	16.60	+ 3.32	14.60	- 1.73	12.23	- 3.94
3B	17.05	+ 3.77	15.00	- 1.33	10.30	- 5.87
4B	18.10	+ 4.82	13.93	- 2.40	10.72	- 5.45
5B	15.15	+ 1.87	16.74	+ 0.41	12.67	- 3.50
6B	18.30	+ 5.02	12.61	- 3.72	12.23	- 3.94
7B	12.60	- 0.68	16.80	+ 0.47	15.23	- 0.94
8B	14.80	+ 1.52	14.87	- 1.46	15.88	- 0.29
9B	10.60	- 2.68	18.41	+ 2.08	17.80	+ 1.63
10B	14.15	+ 0.87	15.82	- 0.51	13.74	- 2.43
11B	11.55	- 1.73	18.30	+ 1.97	17.80	+ 1.63
12B	12.30	- 0.98	16.20	- 0.13	17.80	+ 1.63
13B	9.00	- 4.28	17.80	+ 1.47	22.30	+ 6.13
14B	9.85	- 3.43	16.86	+ 0.53	22.30	+ 6.13
15B	9.55	- 3.73	16.68	+ 0.35	22.92	+ 6.33
16B	7.85	- 5.43	20.48	+ 4.15	22.50	+ 6.33
Average	13.28	2.87	16.33	1.43	16.17	3.78
Raw Materials						
AN	32.70					
SP			50.50			
KCl					58.40	

TABLE VIII. VERTICAL TOWER TESTS: SCREEN ANALYSES

	% of Total						
Sample No.	+ 8 mesh	- 8 + 10	- 10 + 12	- 12 + 14	- 14 + 16	- 16 + 20	- 20
TEST 2							
1A	17.6	45.2	12.3	10.9	6.9	3.0	4.0
2A	22.1	46.2	10.9	10.1	6.1	2.5	2.6
3A	25.3	42.2	9.6	8.9	5.5	2.7	5.9
4A	32.9	44.8	8.3	7.1	3.8	1.6	1.6
5A	27.9	43.8	10.0	8.2	4.9	2.3	2.8
6A	32.0	48.3	9.0	6.0	2.8	1.1	0.9
7A	21.2	44.9	10.9	10.1	5.7	2.9	4.2
8A	24.4	48.9	10.2	8.0	3.5	2.9	2.1
9A	15.4	39.0	12.4	12.8	8.3	3.9	7.9
10A	18.0	45.5	11.3	10.7	6.9	3.3	4.2
11A	14.5	42.1	12.1	13.2	7.6	3.8	6.3
12A	16.7	44.0	12.1	11.9	7.3	3.9	4.1
13A	20.0	45.2	10.1	9.4	6.3	3.3	5.5
14A	17.0	45.6	12.7	11.3	6.6	3.3	3.5
15A	17.7	42.4	11.8	12.0	6.2	3.8	6.1
16A	13.1	39.4	12.6	12.4	8.2	4.6	9.5
Average	21.0	44.2	11.0	10.2	6.0	3.1	4.5
Raw Materials							
AN	37.3	48.8	7.4	4.1	1.6	0.4	0.2
SP	10.4	28.8	15.7	19.6	12.3	6.1	7.3
KCl	16.2	52.7	9.9	6.4	4.3	2.8	7.7
Wt. Avg.	24.1	44.0	10.4	9.2	5.4	2.7	4.2

TABLE IX. CONE MIXER TESTS: CHEMICAL ANALYSES

Sample No.	% N	Deviation from N Average	Total % P_2O_5	Deviation from P_2O_5 Average	% K_2O	Deviation from K_2O Average
TEST 1						
1B	17.64	+ 2.61	13.80	- 1.70	12.80	- 2.42
2B	17.60	+ 2.57	12.84	- 2.66	14.70	- 0.52
3B	17.36	+ 2.33	13.13	- 2.37	14.70	- 0.52
4B	18.41	+ 3.38	11.74	- 3.76	12.30	- 2.92
5B	16.81	+ 1.78	13.74	- 1.76	15.30	+ 0.08
6B	13.71	- 1.32	16.46	+ 0.96	15.90	+ 0.68
7B	13.97	- 1.06	16.43	+ 0.93	17.60	+ 2.38
8B	12.65	- 2.38	17.69	+ 2.19	18.50	+ 3.28
9B	14.29	- 0.74	16.08	+ 0.58	15.50	+ 0.28
10B	14.73	- 0.30	16.33	+ 0.83	14.80	- 0.42
11B	12.50	- 2.53	19.63	+ 4.13	15.00	- 0.22
12B	10.65	- 4.38	18.16	+ 2.66	15.50	+ 0.28
Average	15.03	2.12	15.50	2.04	15.22	1.17
TEST 2						
1B	15.69	+ 1.34	14.62	- 1.90	15.80	+ 0.78
2B	17.37	+ 3.02	13.57	- 2.95	12.90	- 2.12
3B	17.01	+ 2.66	13.45	- 3.07	15.40	+ 0.38
4B	16.40	+ 2.05	13.43	- 3.09	14.50	- 0.52
5B	17.62	+ 3.27	13.28	- 3.24	13.40	- 1.62
6B	16.20	+ 1.85	14.03	- 2.49	12.80	- 2.22
7B	15.58	+ 1.23	15.79	- 0.73	14.40	- 0.62
8B	13.60	- 0.75	18.01	+ 1.49	12.80	- 2.22
9B	13.91	- 0.44	16.73	+ 0.21	17.10	+ 2.08
10B	13.65	- 0.70	15.70	- 0.82	17.30	+ 2.28
11B	12.69	- 1.66	17.49	+ 0.97	17.80	+ 2.78
12B	13.25	- 1.10	17.37	+ 0.85	17.70	+ 2.68
13B	12.50	- 1.85	18.81	+ 2.29	15.80	+ 0.78
14B	14.35	0.00	16.67	+ 0.15	14.40	- 0.62
15B	12.40	- 1.95	19.63	+ 3.11	15.00	- 0.02
16B	11.21	- 3.14	21.27	+ 4.75	13.40	- 1.62
17B	10.58	- 3.77	20.96	+ 4.44	14.80	- 0.22
Average	14.35	1.81	16.52	2.15	15.02	1.39
Raw Materials						
AN	33.49					
SP			51.66			
KCl					59.4	

TABLE X. CONE MIXER TESTS: SCREEN ANALYSES

Sample No.	+ 8 mesh	- 8 + 10	- 10 + 12	- 12 + 14	- 14 + 16	- 16 + 20	- 20
	% of Total						
TEST 2							
1A	20.9	37.4	10.6	10.6	8.0	4.1	8.4
2A	27.2	45.0	9.0	7.6	5.1	2.0	4.1
3A	29.7	43.3	8.9	7.3	4.5	2.5	3.8
4A	28.4	46.3	8.7	7.1	4.3	2.2	3.0
5A	29.9	44.3	8.8	7.3	4.4	2.0	3.3
6A	26.1	44.4	9.7	8.1	6.2	2.1	3.4
7A	27.3	42.1	9.8	9.0	5.5	2.8	3.5
8A	24.6	41.2	10.0	9.4	6.4	3.2	5.2
9A	24.5	46.3	11.0	8.8	4.9	2.0	2.5
10A	24.4	45.1	10.9	9.6	5.8	1.9	2.3
11A	19.3	42.2	12.0	11.6	7.6	3.5	3.8
12A	21.1	42.4	10.7	10.8	7.0	3.7	4.3
13A	20.6	40.7	11.5	10.8	8.2	3.2	5.0
14A	22.4	40.9	10.4	9.8	6.7	3.6	6.2
15A	17.6	37.1	11.1	11.1	8.2	3.7	11.2
16A	14.1	34.3	10.3	11.3	8.6	5.4	16.0
17A	8.2	23.5	8.3	10.2	9.1	6.6	34.1
Average	22.7	41.0	10.1	9.4	6.5	3.2	7.1
Raw Materials							
AN	36.7	49.9	7.2	3.8	1.8	0.4	0.2
SP	10.0	28.3	15.9	20.3	12.5	6.2	6.8
KCl	17.0	50.9	10.8	6.6	4.4	2.7	7.6
Wt. Avg.	23.9	43.9	10.6	9.3	5.6	2.7	4.0

TABLE XI. SCREW CONVEYOR MIXER TESTS: CHEMICAL ANALYSES

Sample No.	% N	Deviation from N Average	Total % P_2O_5	Deviation from P_2O_5 Average	% K_2O	Deviation from K_2O Average
TEST 1						
1	18.25	+ 0.93	18.82	+ 0.68	9.60	- 1.88
2	17.35	+ 0.03	17.80	- 0.34	10.80	- 0.68
3	17.35	+ 0.03	18.68	+ 0.54	11.60	+ 0.12
4	16.95	- 0.37	18.93	+ 0.79	11.60	+ 0.12
5	17.15	- 0.17	18.70	+ 0.56	11.60	+ 0.12
6	16.70	- 0.62	17.84	- 0.30	11.20	- 0.28
7	17.25	- 0.07	16.75	- 1.39	11.40	- 0.08
8	16.85	- 0.47	18.05	- 0.09	10.60	- 0.88
9	17.25	- 0.07	18.13	- 0.01	10.80	- 0.68
10	17.40	+ 0.08	18.90	+ 0.76	11.20	- 0.28
11	17.60	+ 0.28	17.60	- 0.54	11.40	- 0.08
12	17.45	+ 0.13	17.75	- 0.39	11.60	+ 0.12
13	17.40	+ 0.08	18.30	+ 0.16	12.00	+ 0.52
14	17.20	- 0.12	18.50	+ 0.36	11.20	- 0.28
15	17.05	- 0.27	18.08	- 0.06	12.20	+ 0.72
16	17.60	+ 0.28	17.60	- 0.54	11.60	+ 0.12
17	17.30	- 0.02	18.25	+ 0.11	11.00	- 0.48
18	17.75	+ 0.43	18.00	- 0.14	11.60	+ 0.12
19	17.05	- 0.27	16.65	- 1.49	11.60	+ 0.12
20	17.25	- 0.07	16.96	- 1.18	12.20	+ 0.72
21	17.10	- 0.22	17.46	- 0.68	13.40	+ 1.92
22	17.25	- 0.07	19.10	+ 0.96	11.40	- 0.08
23	17.75	+ 0.43	18.50	+ 0.36	11.80	+ 0.32
24	17.45	+ 0.13	18.50	+ 0.36	12.20	+ 0.72
25	17.40	+ 0.08	19.75	+ 1.61	11.40	- 0.08
Average	17.32	0.23	18.14	0.52	11.48	0.46
Raw Materials						
AN	33.6					
SP			56.4			
KCl					59.2	

TABLE XII. SCREW CONVEYOR MIXER TEST: SCREEN ANALYSES

	% of Total						
Sample No.	+ 8 mesh	- 8 + 10	- 10 + 12	- 12 + 14	- 14 + 16	- 16 + 20	- 20
TEST 2							
1A	18.7	47.3	12.7	9.4	5.8	2.6	3.5
2A	32.5	42.2	10.1	7.2	3.8	1.7	2.5
3A	15.0	44.8	13.0	11.7	6.8	3.1	5.6
4A	17.8	45.7	11.5	12.0	6.2	3.0	3.8
5A	14.0	43.2	14.5	12.7	7.6	3.6	4.4
6A	22.4	47.9	11.2	8.8	4.7	2.2	2.8
7A	18.5	48.1	13.1	10.1	5.2	2.3	2.7
8A	23.6	45.5	9.7	7.9	4.9	3.0	5.4
9A	30.2	48.7	7.3	2.8	6.0	2.0	3.0
10A	22.9	49.8	11.2	8.3	4.3	1.6	1.9
11A	27.1	45.7	9.7	7.9	4.4	2.2	3.0
12A	37.2	44.5	7.2	5.2	2.7	1.3	1.9
13A	43.0	38.9	5.9	4.7	2.9	1.5	3.1
14A	32.0	40.5	10.6	8.0	4.1	2.2	2.6
15A	25.9	31.6	12.5	11.0	6.1	3.4	9.5
16A	27.6	39.1	10.6	7.6	4.0	2.8	8.3
Average	25.5	44.0	10.7	8.5	5.0	2.4	4.0
Raw Materials							
AN	28.8	51.6	9.6	6.1	2.8	0.8	0.3
SP	10.4	31.1	15.3	17.4	12.0	5.8	8.0
KCl	16.9	48.6	10.5	7.5	5.0	3.4	8.1
Wt. Avg.	20.4	44.9	11.5	9.7	6.0	2.9	4.5

TABLE XIII. MUNSON ROTARY MIXER TESTS: CHEMICAL ANALYSES

Sample No.	% N	Deviation from N Average	Total % P_2O_5	Deviation from P_2O_5 Average	% K_2O	Deviation from K_2O Average
TEST 1						
1B	14.95	+ 0.66	17.56	+ 0.51	14.80	- 0.78
2B	14.85	+ 0.56	17.31	+ 0.26	14.80	- 0.78
3B	14.10	- 0.19	16.92	- 0.13	14.80	- 0.78
4B	14.85	+ 0.56	17.70	+ 0.65	15.20	- 0.38
5B	14.05	- 0.24	18.23	+ 1.18	15.80	+ 0.22
6B	14.05	- 0.24	19.70	+ 2.65	15.40	- 0.18
7B	14.55	+ 0.26	16.92	- 0.13	15.20	- 0.38
8B	14.30	+ 0.01	16.42	- 0.63	15.80	+ 0.22
9B	14.75	+ 0.46	16.30	- 0.75	15.60	+ 0.02
10B	14.20	- 0.09	16.12	- 0.93	15.80	+ 0.28
11B	14.95	+ 0.66	16.20	- 0.85	15.40	- 0.18
12B	14.90	+ 0.61	16.20	- 0.85	16.00	+ 0.42
13B	14.30	+ 0.01	16.00	- 1.05	16.20	+ 0.62
14B	14.75	+ 0.46	15.73	- 1.32	15.40	- 0.18
15B	14.65	+ 0.36	16.12	- 0.93	15.60	+ 0.02
16B	14.15	- 0.14	15.94	- 1.11	15.40	- 0.18
17B	14.05	- 0.24	16.42	- 0.63	16.00	+ 0.42
18B	13.55	- 0.74	17.39	+ 0.34	16.00	+ 0.42
19B	12.75	- 1.54	18.80	+ 1.75	16.40	+ 0.82
20B	13.00	- 1.29	19.00	+ 1.95	16.00	+ 0.42
Average	14.29	0.47	17.05	0.93	15.58	0.39
TEST 2						
1B	14.50	+ 0.14	16.50	- 0.70	15.20	+ 0.29
2B	13.75	- 0.61	18.10	+ 0.90	15.60	+ 0.69
3B	14.35	- 0.01	17.25	+ 0.05	15.80	+ 0.89
4B	14.95	+ 0.59	16.80	- 0.40	15.60	+ 0.69
5B	14.80	+ 0.44	17.08	- 0.12	15.20	+ 0.29
6B	14.20	- 0.16	17.25	+ 0.05	15.40	+ 0.49
7B	14.05	- 0.31	17.39	+ 0.19	15.20	+ 0.29
8B	14.15	- 0.21	16.62	- 0.58	15.00	+ 0.09
9B	14.15	- 0.21	17.43	+ 0.23	15.00	+ 0.09
10B	14.70	+ 0.34	17.50	+ 0.30	15.00	+ 0.09
11B	14.20	- 0.16	17.70	+ 0.50	15.00	+ 0.09
12B	14.25	- 0.11	16.80	- 0.40	14.60	- 0.31
13B	14.95	+ 0.59	16.55	- 0.65	15.00	+ 0.09
14B	14.50	+ 0.14	16.75	- 0.45	14.60	- 0.31
15B	14.20	- 0.16	16.12	- 1.08	14.80	- 0.11
16B	14.20	- 0.16	17.39	+ 0.19	14.40	- 0.51
17B	14.35	- 0.01	17.31	+ 0.11	14.40	- 0.51
18B	14.45	+ 0.09	17.39	+ 0.19	14.00	- 0.91
19B	14.75	+ 0.39	18.23	+ 1.03	14.00	- 0.91
20B	13.80	- 0.56	17.88	+ 0.68	14.40	- 0.51
Average	14.36	0.27	17.20	0.44	14.91	0.41
Raw Materials						
AN	33.50					
SP			55.05			
KCl					57.60	

TABLE XIV. MUNSON MIXER TESTS: SCREEN ANALYSES

Sample No.	% of Total + 8 mesh	- 8 + 10	- 10 + 12	- 12 + 14	- 14 + 16	- 16 + 20	- 20
TEST 2							
1A	22.0	47.6	11.3	8.9	5.2	2.3	2.7
2A	21.8	47.5	11.3	8.4	5.3	2.5	3.2
3A	19.4	47.2	11.6	9.7	5.9	2.8	3.5
4A	24.3	48.3	10.7	7.8	4.4	1.9	2.5
5A	19.7	46.8	11.7	9.8	5.5	2.7	3.9
6A	22.0	45.5	11.5	9.6	5.5	2.6	3.4
7A	20.0	47.5	10.9	9.4	5.6	2.7	4.0
8A	21.8	46.7	11.2	9.0	5.6	2.5	3.2
9A	20.3	47.4	11.2	9.5	5.8	2.5	3.4
10A	20.9	47.0	11.6	9.5	5.4	2.5	3.1
11A	19.3	46.6	11.9	10.0	6.1	2.8	3.4
12A	18.4	46.0	12.7	10.4	6.0	2.9	3.6
13A	18.7	46.8	11.1	9.9	6.7	2.9	4.0
14A	22.5	45.9	11.2	9.4	5.3	2.3	3.4
15A	21.3	47.0	11.3	9.0	5.4	2.5	3.6
16A	16.8	44.4	11.9	11.7	6.8	3.3	5.2
17A	22.7	46.1	11.0	9.2	5.2	2.5	3.4
18A	17.7	45.1	12.6	10.4	6.5	3.1	4.5
19A	17.2	44.3	12.5	10.8	7.4	3.3	4.5
20A	14.0	36.9	13.1	13.9	10.0	5.3	6.8
Average	20.0	46.0	11.6	9.8	6.0	2.8	3.8
Raw Materials							
AN	29.8	51.5	8.2	5.1	3.1	1.3	1.1
SP	12.1	32.0	14.5	18.2	10.6	5.1	7.5
KCl	19.5	51.7	9.2	6.1	3.8	2.7	7.0
Wt. Avg.	22.0	45.9	10.3	8.9	5.5	2.8	4.5

TABLE XV. COMPARISON OF TESTS ON VARIOUS MIXERS

	TEST 1			TEST 2		
Mixer[a]	% N	% Total P_2O_5	% K_2O	% N	% Total P_2O_5	% K_2O
Screw						
Average analysis	17.32	18.14	11.48	-----	-----	-----
Average deviation	0.23	0.52	0.46	-----	-----	-----
Munson Rotary						
Average analysis	14.29	17.05	15.58	14.36	17.20	14.91
Average deviation	0.47	0.93	0.39	0.27	0.44	0.41
Cylindrical Rotary						
Average analysis	15.60	15.53	15.39	15.18	16.52	15.16
Average deviation	0.52	0.71	0.59	0.37	1.49	1.07
Ribbon						
Average analysis	14.19	15.67	15.06	15.05	16.09	15.42
Average deviation	0.97	1.53	2.43	0.77	1.14	0.81
Concrete						
Average analysis	15.19	18.05	14.67	15.84	15.21	15.10
Average deviation	1.01	3.11	1.65	1.05	1.79	0.49
Cone						
Average analysis	15.03	15.50	15.22	14.35	16.52	15.02
Average deviation	2.12	2.04	1.17	1.81	2.15	1.39
Vertical Tower						
Average analysis	13.34	16.33	16.18	13.28	16.33	16.17
Average deviation	2.27	1.33	3.23	2.87	1.43	3.78

[a] Listed in order of decreasing mixing efficiency.

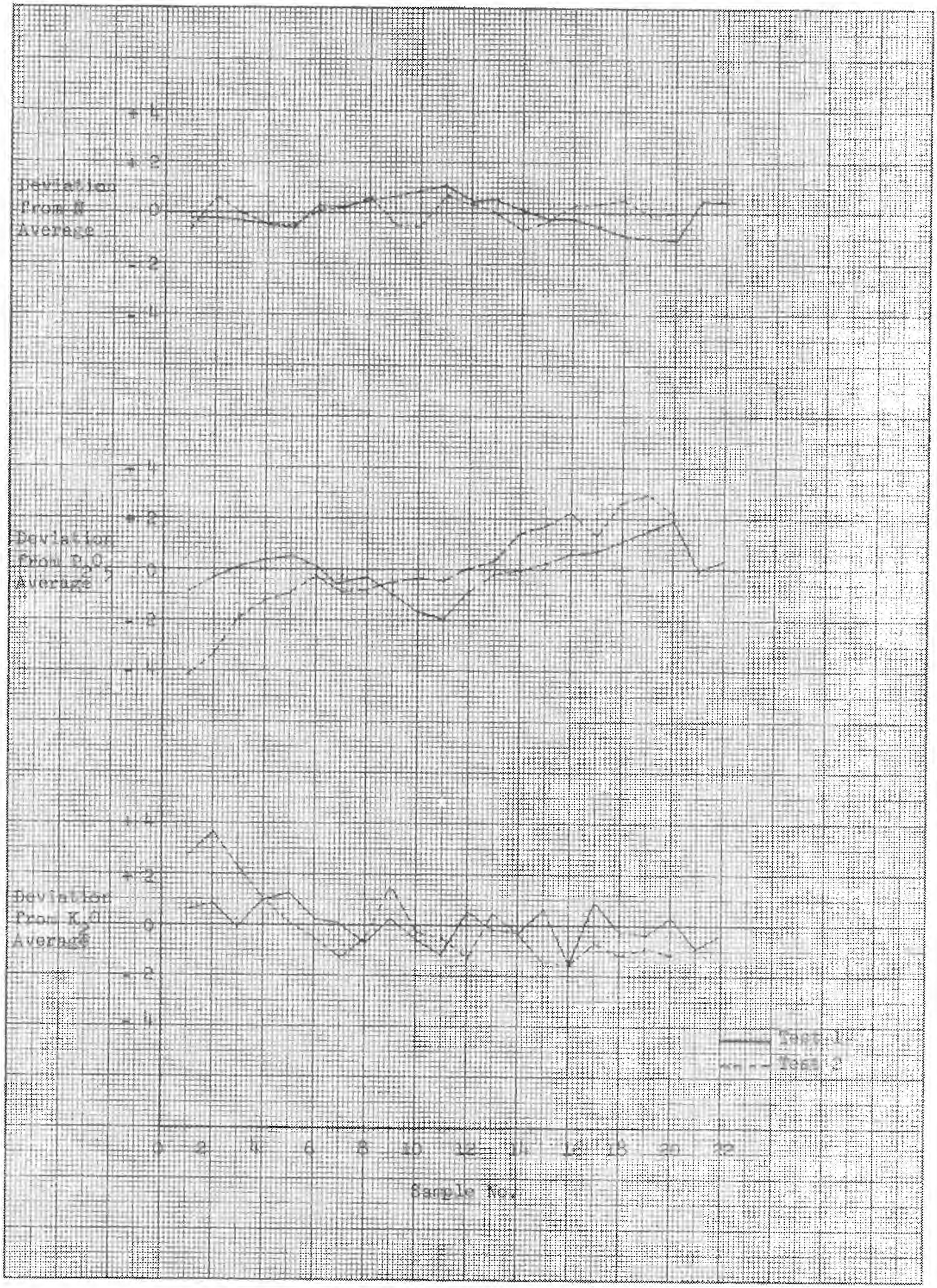

Figure 1. Cylindrical Rotary Mixer Tests: Deviations in Chemical Analysis from Average

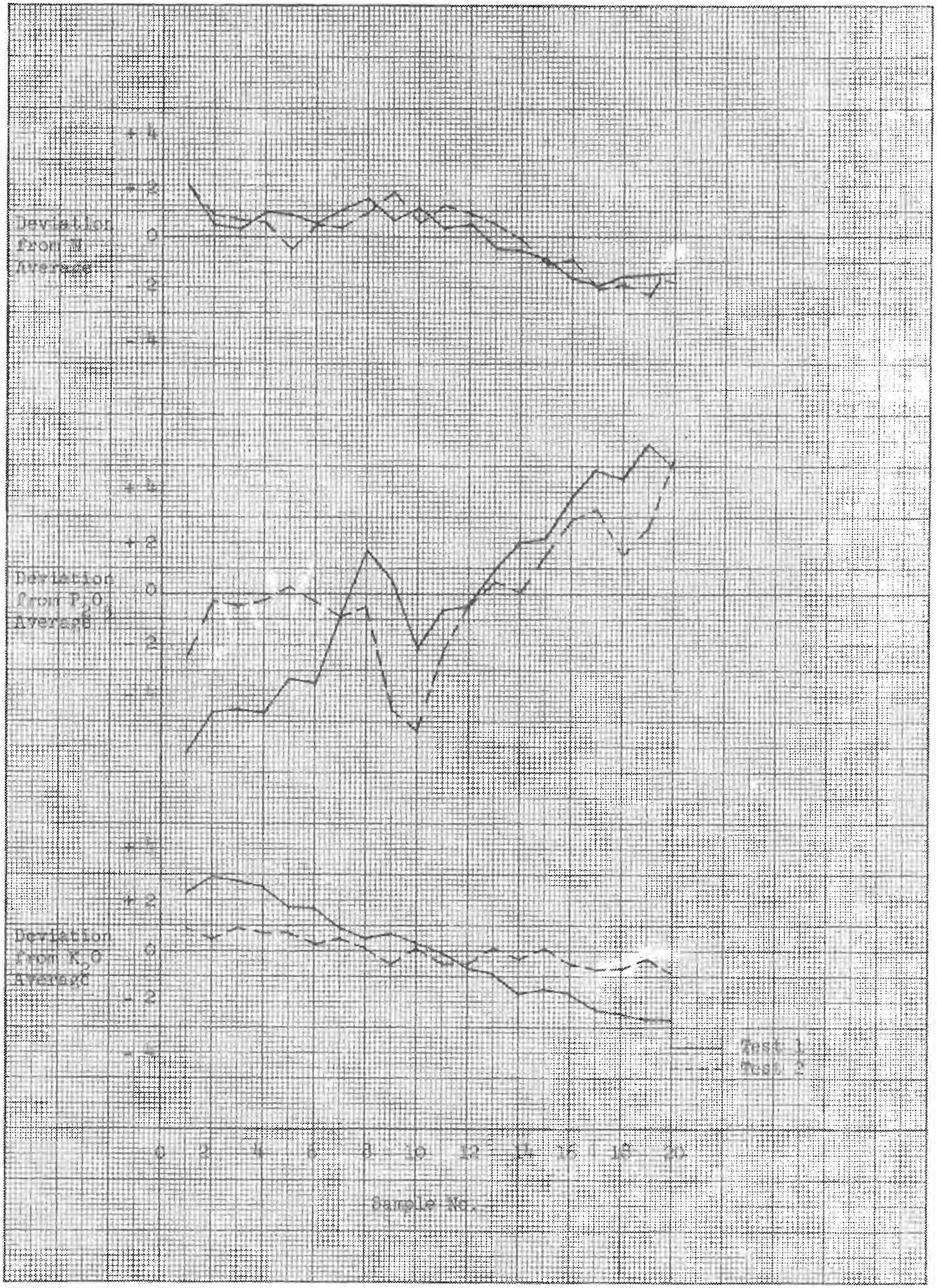

Figure 2. Concrete Mixer Tests: Deviations in Chemical Analysis from Average

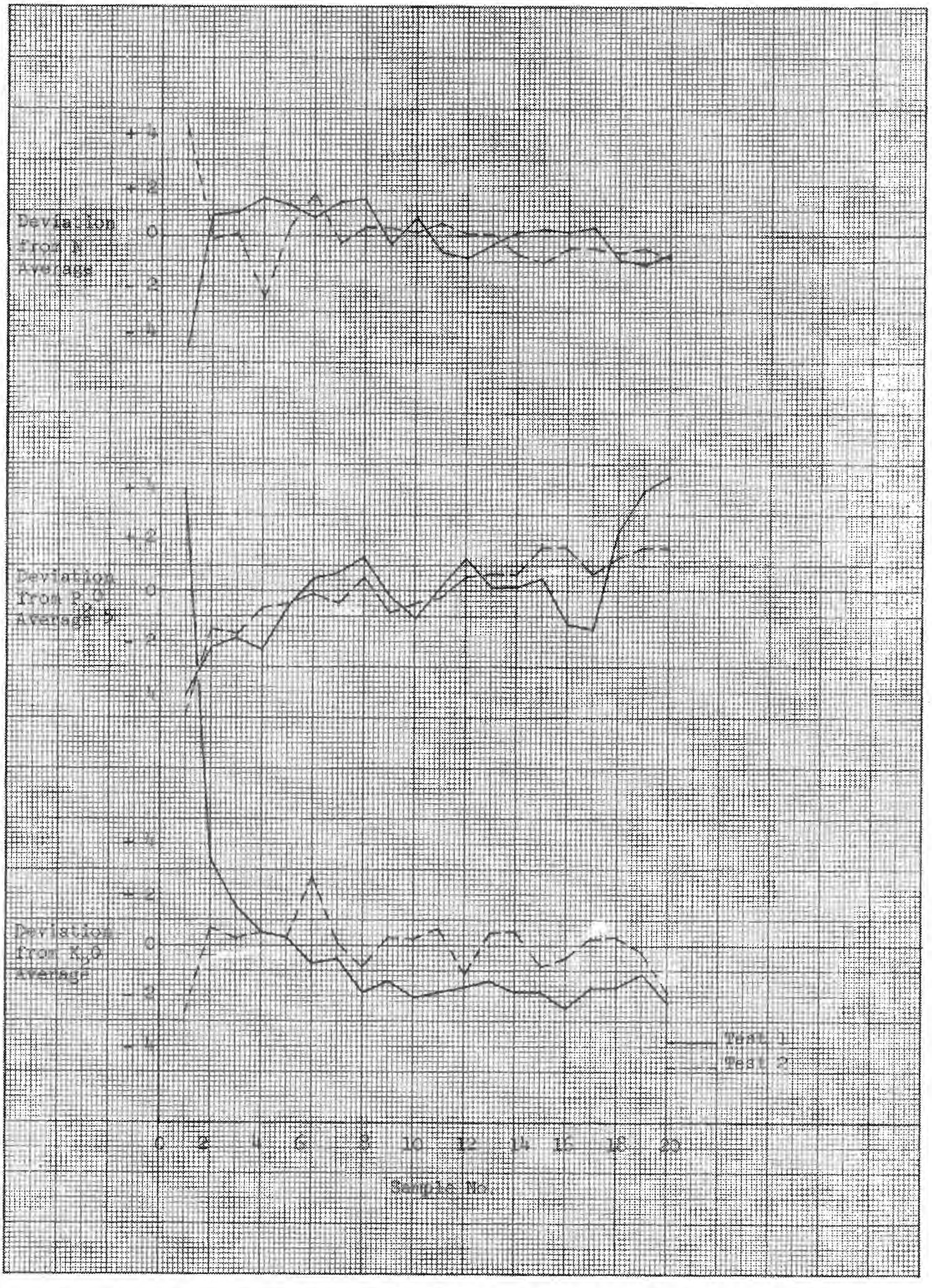

Figure 3. Ribbon Mixer Tests: Deviations in Chemical Analysis from Average

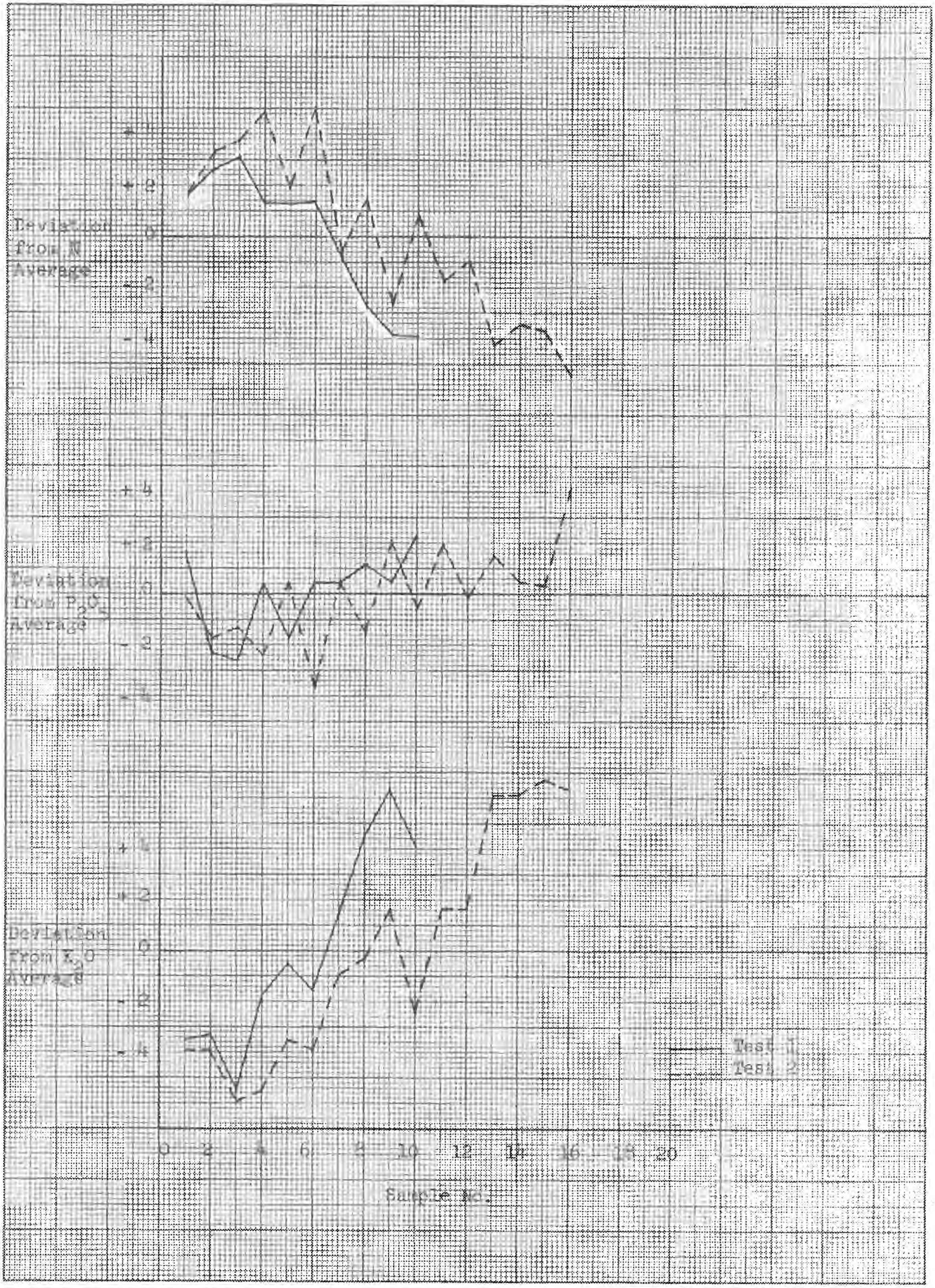

Figure 4. Vertical Tower Mixer Tests: Deviations in Chemical Analysis from Average

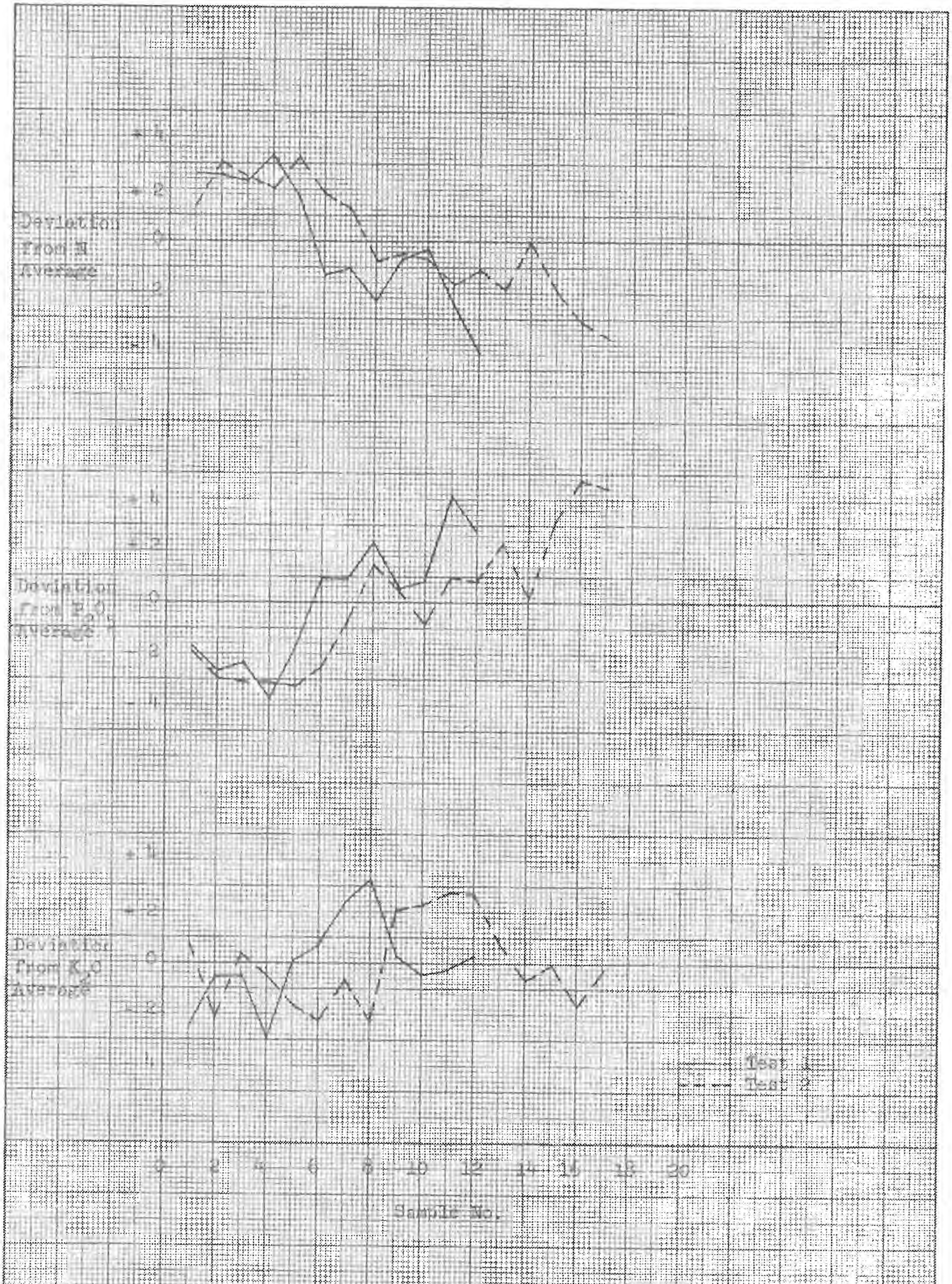

Figure 5. Cone Mixer Tests: Deviations in Chemical Analysis from Average

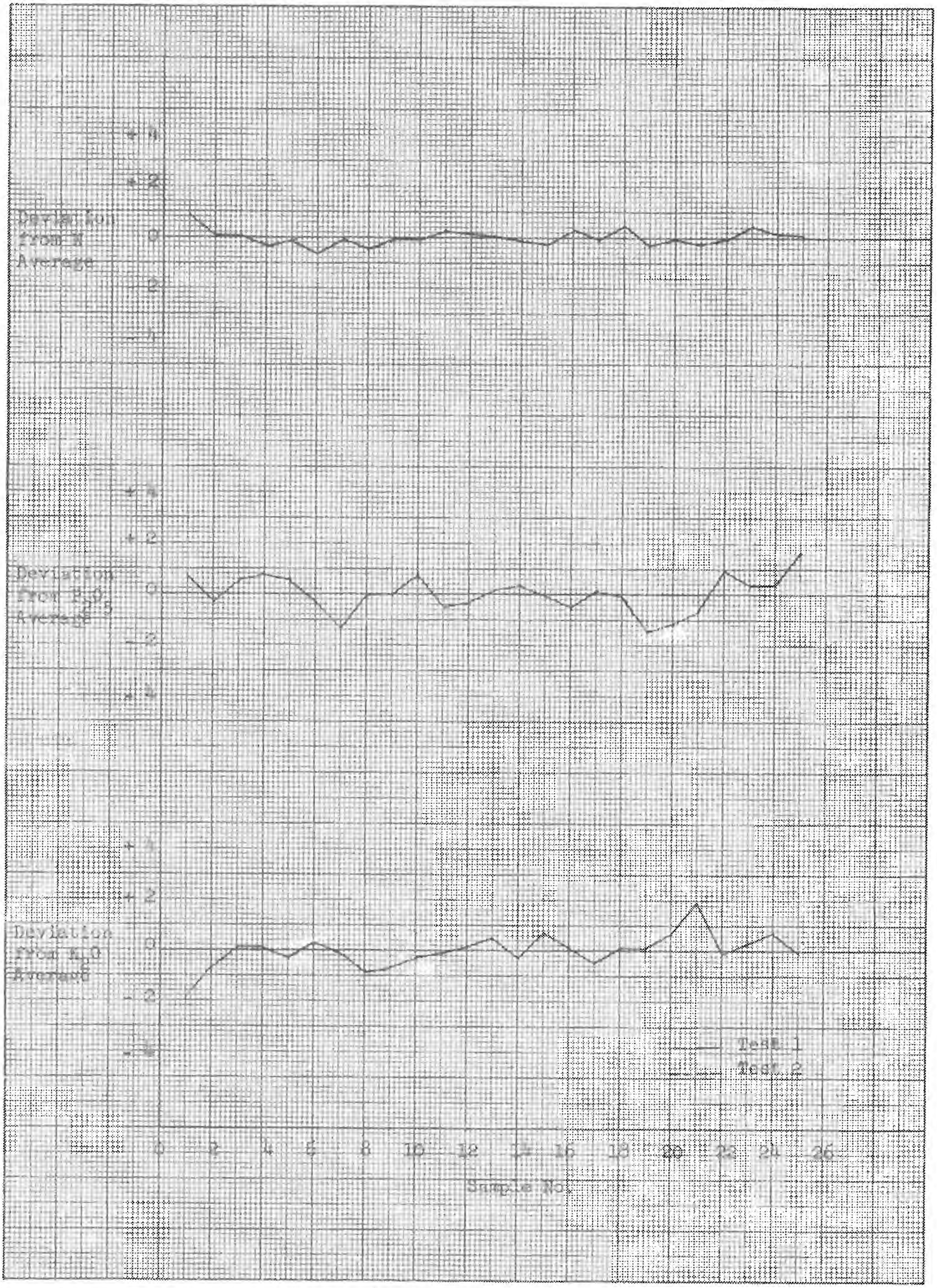

Figure 6. Screw Conveyor Tests: Deviations in Chemical Analysis from Average

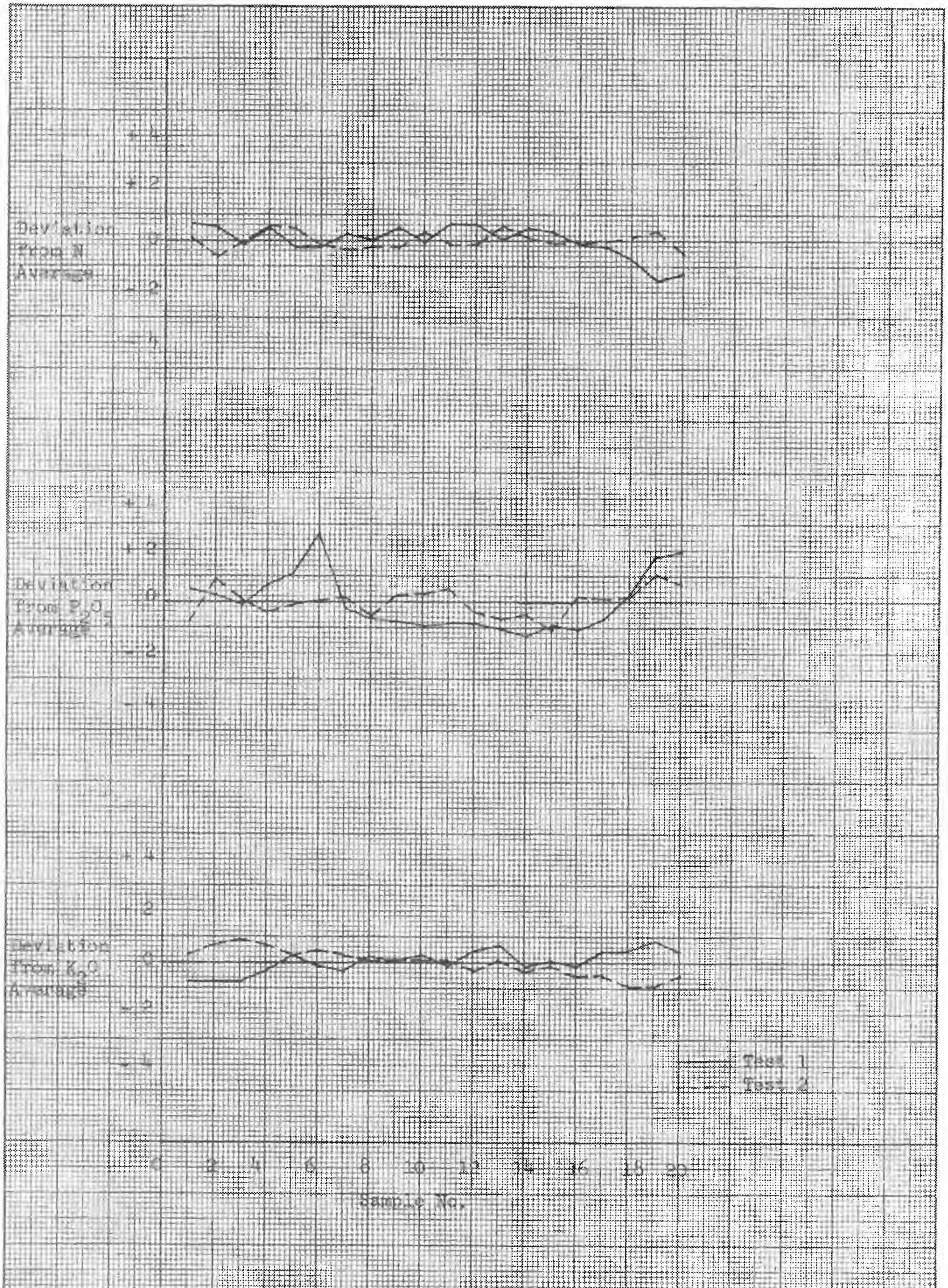

Figure 7. Munson Mixer Tests: Deviations in Chemical Analysis from Average